TRAIL COUNT REPORT: 2000 - 2001

INTRODUCTION

Pinnacles National Monument (PNM) is a day-use park (no overnight camping), where the primary visitor activities are hiking and climbing. Prior to 2000, a system to monitor visitor use of PNM trails was lacking. There were attempts to set up counters on the trails prior to 2000, but these failed to provide consistent results, due primarily to the lack of an effective mounting system. Quantitative data on trail use is important for assessing potential impacts on wildlife and plant communities, as well as for maintaining the quality of visitor experience, particularly on wilderness trails. This report describes an effective system for monitoring recreational trail use, and presents trail monitoring results for 2000 and 2001.

METHODS

PNM Trail System

PNM has over 32 miles of trails. North and South Wilderness are the two main trail systems in the remote portions of PNM – they are both undeveloped primitive trails. Bear Gulch, Moses Spring, Old Pinn, Balconies Trail/Cave are well developed trails in riparian corridors. Condor Gulch, High Peaks, Chalone Peak and Juniper Canyon trails are developed trails that access the higher elevations of the monument.

Trail Monitoring System

In late 1999 and early 2000, I installed 12 infra-red trail counters (Trailmaster ® 1500 series receivers and transmitters manufactured by Goodwin Goodson and Assoc., Lenexa, KS) on the major trails at PNM: Balconies Cave, Balconies, Bear Gulch, Chalone Peak, Condor Gulch, Juniper Canyon, High Peaks – Chalone, Moses Spring, North Wilderness, Old Pinn, Rim Trail, South Wilderness (Figure 1). Metal boxes were custom manufactured to hold the counters for mounting and security. I mounted the units on bridges or wooden fences when this option was available (Figure 2). Otherwise, units were U-bolted to metal fence posts/ t-stakes (Figure 3). In both mounting scenarios, the receiver was positioned on one side of the trail and the emitter on the other, installed at such a height as to avoid counting deer or feral pigs. Besides minimizing unit movement due to wind, this mounting system facilitated unit realignment after battery changes (every 2 months).
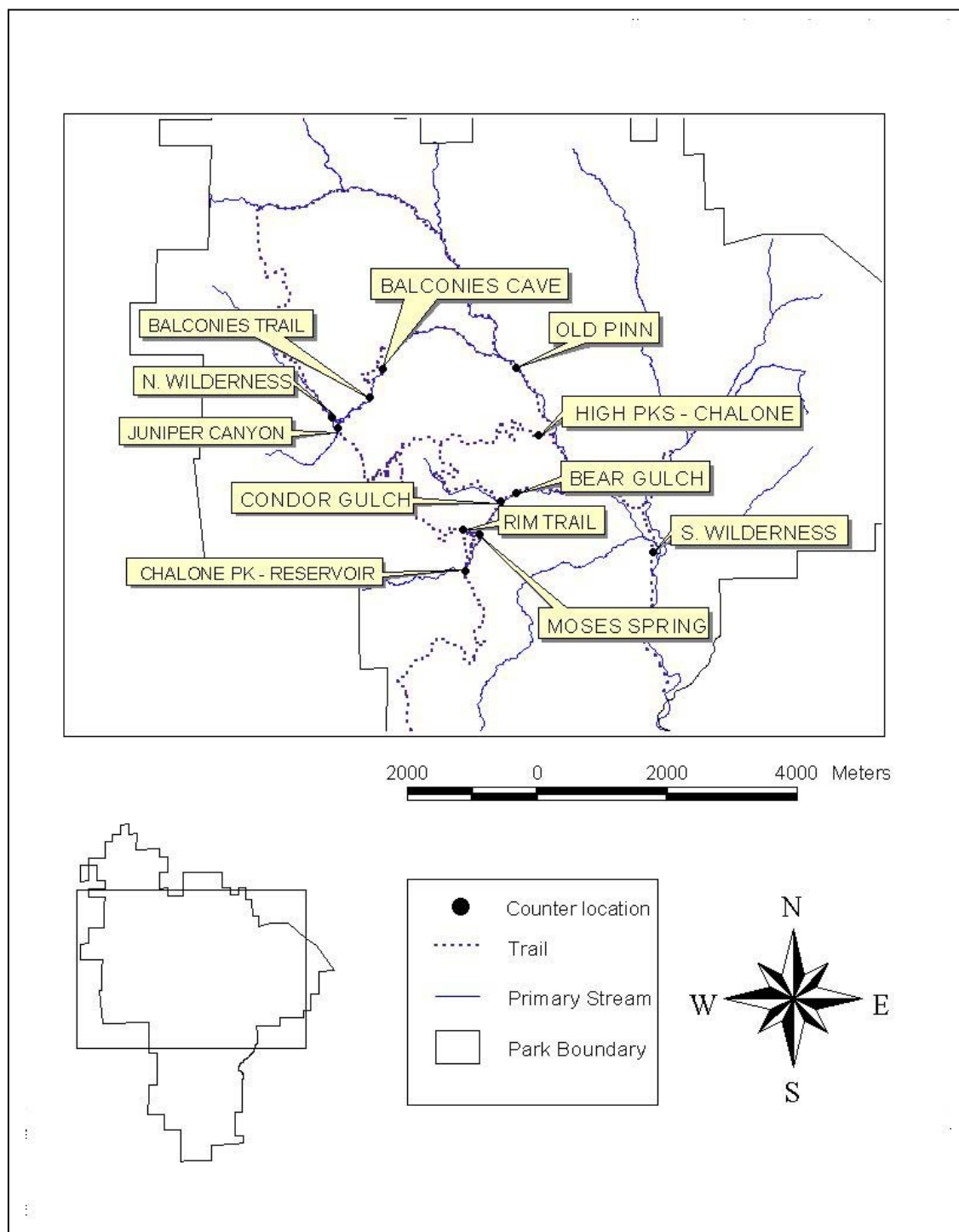
Figure 1. Location of infra-red trail counters and PNM trails.

Figure 2. Trailmaster unit in protective metal box, mounted to footbridge. *Photo by Clay Fletcher*

Figure 3. Trailmaster unit attached to metal fence post (left) using metal box plywood backing and U-bolts (right). *Photos by Clay Fletcher*

The units registered date and time of any event interrupting the infra-red beam. The field receiver units stored count data up to a certain nominal capacity (i.e., units were manufactured to store up to 1K, 4K or 8K events). I attempted to place units on trails according to storage capacity, that is, 4K or 8K units on heavy use and/or distant trails; 1K on close-in (short travel time) or light use trails (Appendix A). Trail count data was collected for 2000 and 2001. In general I downloaded the units to a hand-held data collector at least once per week (Figure 4). During the spring high use period, I downloaded twice per week on popular trails (e.g., Old Pinn or Balconies). Data was transferred to a computer for analysis.
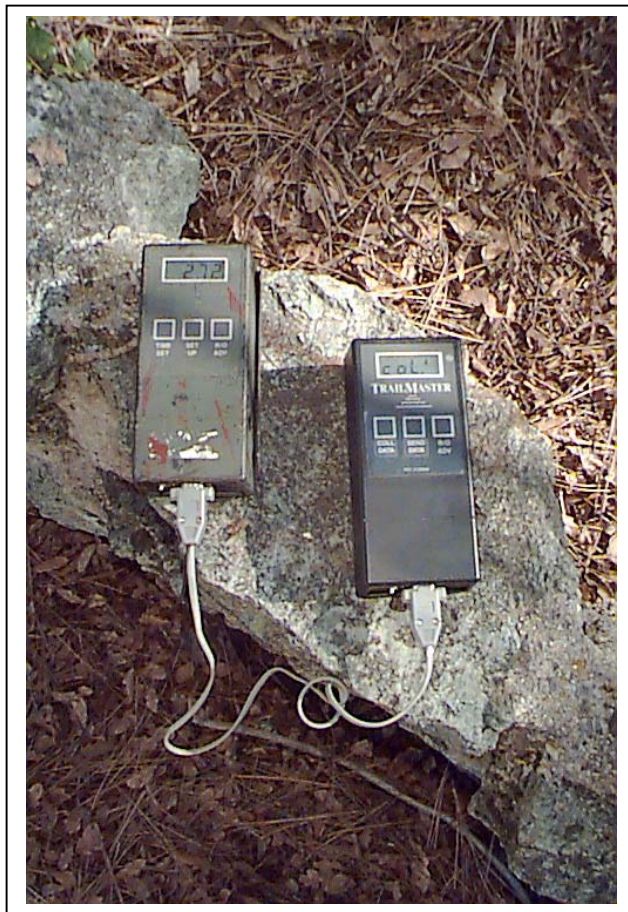

Figure 4. Downloading the receiver unit (left) to the data collector in the field. *Photo by Clay Fletcher*

Data Analysis

Using the Trailmaster ® software program (V. 2.7, 1996), I opened and converted the data to text files. I transferred text files to MS Excel (1997) then to the statistical program Minitab (V. 12.1) for analysis. Some unit locations seemed particularly prone to errors – usually very high counts. In these cases, data was "cleaned" by deleting unusual observations (e.g., counts occurring between 2300 and 0600 hours when the likelihood of counting people was extremely remote) – see Appendix D for details. For between year analysis, I used Mann-Whitney U-tests because of data non-normality and small sample sizes.

RESULTS

Data was summarized by year, trail, and total monthly counts. The monthly counts were subdivided into totals for weekdays and weekends (Appendix B and C). Peaks of trail activity occurred in: April for both 2000 and 2001; and July and November for 2000 (Figure 5, Figure 6).
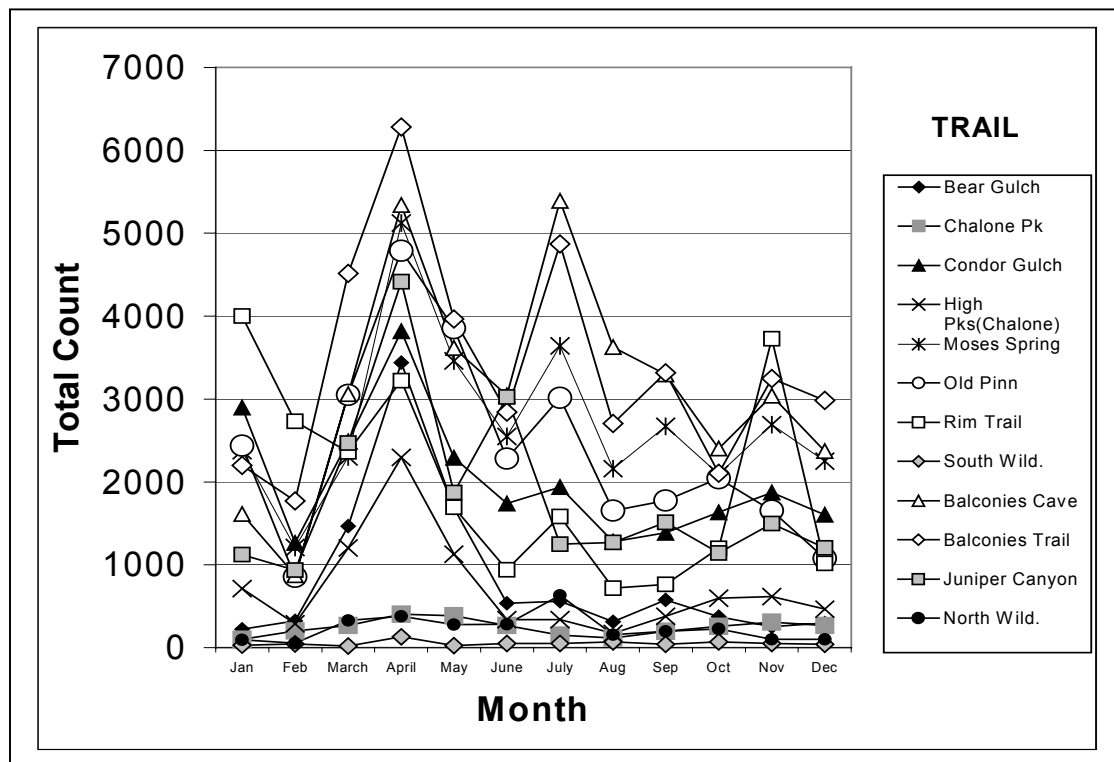
Figure 5. Plot of year 2000 counts/trail/month for major PNM trails.
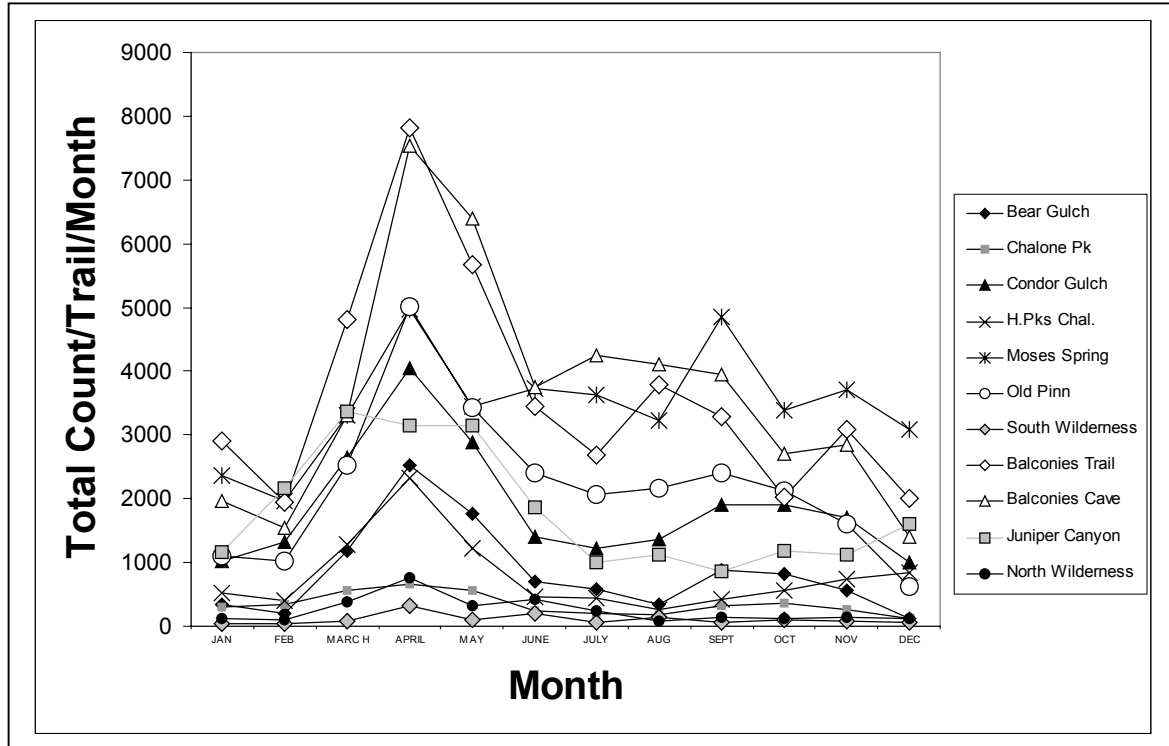
Figure 6. Plot of year 2001 counts/trail/month for major PNM trails.

Mean counts per month for all PNM trails combined were highest for April in both years and lowest for February (Table 1). Mean monthly trail count did not differ significantly between years (U = 146.5, p = 0.862).

Table 1. Mean monthly counts for all PNM trails combined – 2000 and 2001.

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2000	1483	879	1961	3303	2020	1491	1952	1187	1342	1179	1588	1140
2001	1074	1005	2135	3556	2629	1693	1491	1524	1734	1392	1443	999
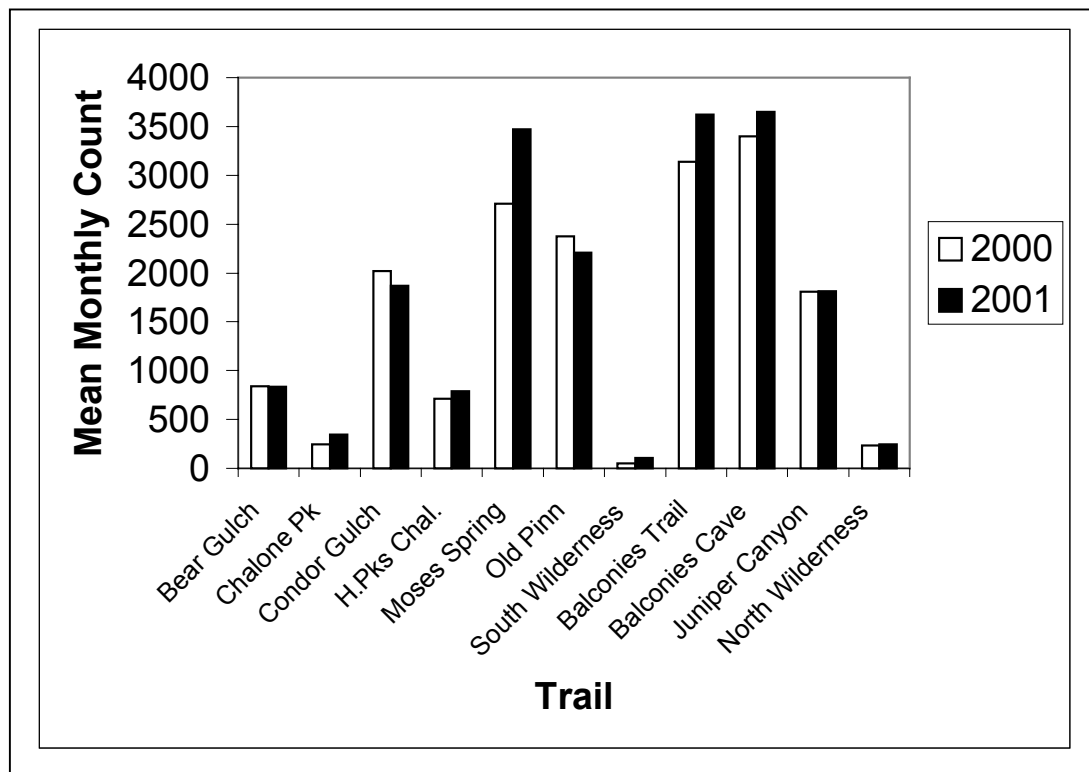
Figure 7. Mean monthly counts for PNM trails per year – 2000 and 2001.

Mean monthly counts for 2000 and 2001 remained approximately equal for Bear Gulch , Juniper Canyon and North Wilderness; was slightly higher in 2001 for Chalone Peak, High Peaks Chalone, Balconies and Balconies Cave and was slightly lower in 2001 for Condor Gulch and Old Pinn.   At $\alpha = 0.10$, Moses Spring (U = 117, p = 0.06) and South Wilderness (U = 188, p = 0.03) both showed significant increases in trail use from 2000 to 2001 (Figure 7, Table 2). Between 2000 and 2001, mean monthly count increased from 2710 to 3471 for Moses Spring and from 52 to 108 for South Wilderness.

Using multivariate cluster analysis on mean monthly use, I divided the trails into 3 groups: High, n = 3; Medium, n = 3; and Low, n = 5; (Table 2). Combined High-use mean (+/- SE) was 3332 +/- 145, range 2710 - 3647; Medium-use mean was 2014 +/-95, range 1808 - 2207; and Low-use mean was 441 +/- 100, range 52 - 836 (Figure 8).

Table 2. 2000 – 2001 mean monthly counts for PNM trails and Use Classification. Rim Trail was excluded from this analysis because no data was collected for 2001, however with a monthly mean count for 2000 of 1977, it would be classified as Medium Use Trail.

Trail	2000	2001	Classification
South Wilderness	52	108	Low
North Wilderness	236	247	Low
Chalone Pk	244	345	Low
H.Pks Chal.	711	790	Low
Bear Gulch	838	836	Low
Juniper Canyon	1808	1813	Medium
Condor Gulch	2017	1868	Medium
Old Pinn	2373	2207	Medium
Moses Spring	2710	3471	High
Balconies Trail	3140	3622	High
Balconies Cave	3400	3647	High
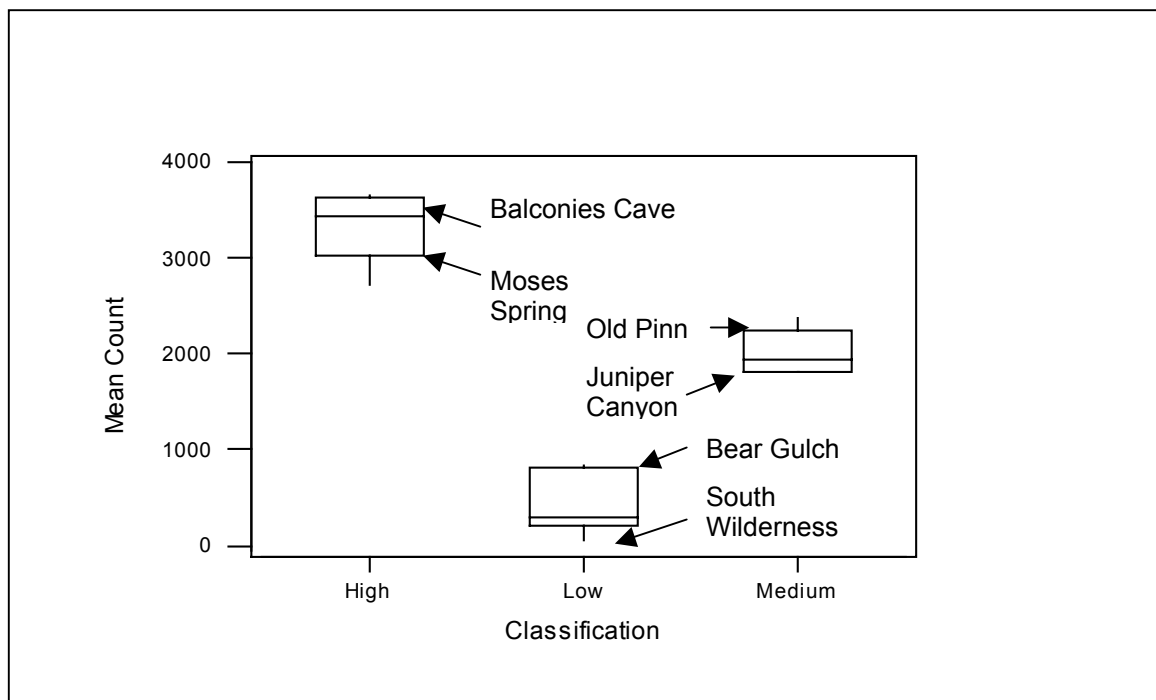
Figure 8. Boxplot of Mean Monthly Count (combined for 2000 and 2001) for High, Medium and Low use trails showing means of high and low trails within each group (lines inside boxes represent the overall mean for each group). Boxes represent first (lower line) and third (upper line) group quartiles. Vertical lines ("whiskers") represent the range of values.

Comparing weekend day and weekday use for the 3 use groups shows no change in use patterns between 2000 and 2001 (Table 3, Figure 9).

Table 3. 2000 and 2001 mean counts per day for weekends and weekdays for the 3 use groups. These values were obtained by dividing mean weekend and weekday counts for each group and year by 8 and 22 respectively.

Group	2000		2001	
	Weekend	Weekday	Weekend	Weekday
High	232	55	277	62
Medium	153	38	156	32
Low	36	6	35	8

Figure 9. Histogram of weekend and weekday mean counts per day for High, Medium and Low use trails – 2000 and 2001.

Assuming an 8-hour hiking day and averaging the combined values for both years, typical encounter rates (people per hour) on weekends (WE) and weekdays (WD) averaged over a whole year would be 32 (WE) and 7 (WD) for High trails; 19 (WE) and 4 (WD) for Medium trails; and 4 (WE) and 1 (WD) for Low trails.

DISCUSSION

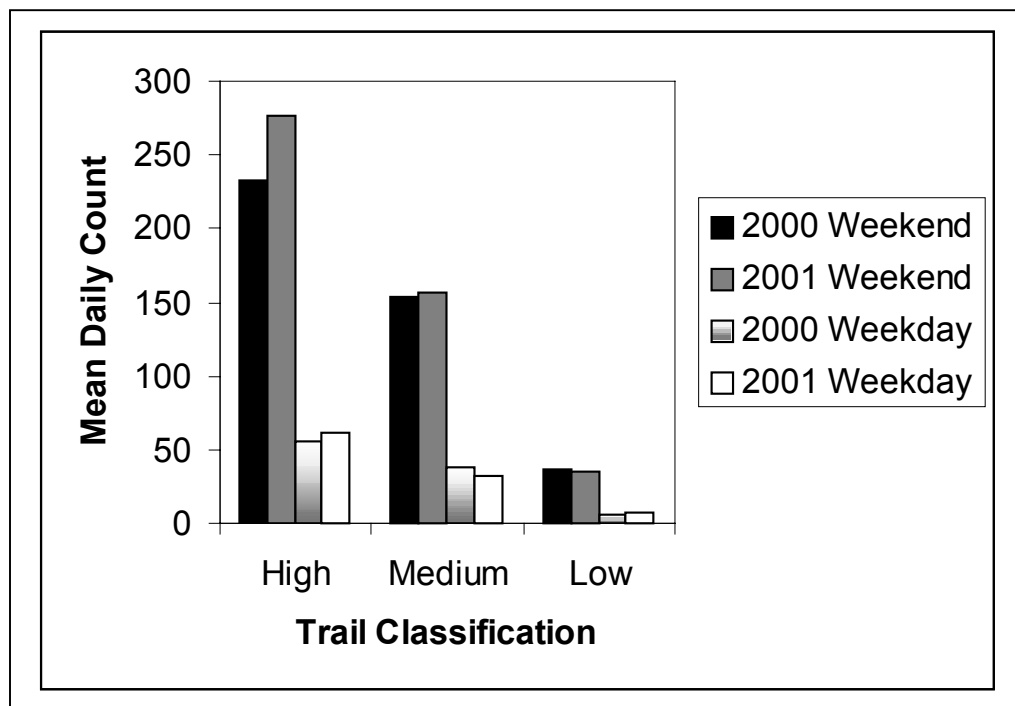Results indicate a consistency of trail counts between years for each trail. There was no significant difference between years in annual counts for each trail, and all trails followed approximately the same monthly pattern in both years – for example, all trails showed a dramatic peak in trail use in April. These patterns indicate that the counters are fairly accurate and give results that can be repeated from year to year.

The data show a wide range in trail use intensity from a low of 80 counts per month for South Wilderness trail to 3523 counts for Balconies Cave trail. The counters count people coming and going (i.e., an individual may be counted twice); thus, the counters provide an index of relative use but do not give an absolute count of people on the various trails. This however is probably irrelevant for predicting the likelihood of encountering other hikers, or for facilitating management decisions necessary for maintaining the quality of visitor experience (particularly on wilderness trails) and for resource protection. Analyses could be extended beyond what is presented here. For example, modeling could predict the probability of encountering other hikers on a trail on a particular day and at a given time of day. Furthermore, preliminary field checks of counter accuracy (conducted by observing the number of hikers walking past a counter then checking the number actually registered by the unit) indicate that the units may be underestimating trail use by counting, for example, 2 or more people walking side by side as 1 person. Modeling could incorporate a correction factor for more accurate predictions.

Studies have shown recreational trail use has the potential to disturb both flora and fauna. Native flora may be disturbed directly through soil compaction and trampling and indirectly through competition with exotic species, which thrive in disturbed areas along trails. Fauna may be disturbed directly by hikers disrupting normal activity patterns and indirectly through increased competition with disturbance tolerant species. Thus, trail count data could be used to correlate disturbance potential with use intensity on the various trails. If sensitive species are present, the possibility exists to implement screening (vegetation) or temporal restrictions on trail use. These data could also be used to plan the location of new trails by predicting potential use and planning accordingly – trails with predicted heavy use could be located so as to avoid sensitive areas and species.

A permit system to regulate the number of people on a trail may be required in order to preserve the quality of visitor experience. Trail count data, such as those presented here, are reliable indicators of threshold use amounts and are necessary for informed management decisions.

I recommend trail count data continue to be collected as a "vital sign" for assessing trail use impacts. If the program continues, some changes would increase the reliability of the data. First, Juniper Canyon, South Wilderness and High Peaks Chalone units should be reinstalled to improve alignment. Second, as previously mentioned, an error rate (the difference between actual number of hikers and the number recorded by the units) should be incorporated into the analysis. Error checking currently being conducted indicate that units undercount the number of people passing by. Error checking should continue in order to establish a reliable error rate for each trail. These results will improve future data quality.

Two counters deployed near the summit on North Chalone Peak are an integral component of the monument's California condor reintroduction program currently being implemented. One counter (North Chalone) is located along the main trail near the boundary fence while the second (South Chalone) is situated on the trail to South Chalone just past the junction with the North Chalone Peak trail. These counters are intended to gauge visitor use of the peaks area and for assessing possible visitor disturbance potential for condor reintroduction and should be maintained throughout the program.

Suggestions for additional counter locations include the Rim Trail, North Wilderness trail 1 to2 miles from the Old Pinn junction and possibly a similar setup on South Wilderness trail to detect trail use in the more remote areas. Depending upon trail counts, it may be advantageous to replace the 4 and 8K units on North and South Chalone with 1K units and move the higher capacity units to Juniper Canyon, Old Pinn, and Rim Trail (if reinstalled).

APPENDIXES

Appendix B. 2000 counts for trails at PNM month showing totals and subtotals by weekend and weekday.

TRAIL	Totals:	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
EAST SIDE													
Bear Gulch	Wkend	164	191	1249	2673	1171	359	292	190	344	297	214	143
	Wkday	58	133	218	768	513	176	270	126	231	77	39	157
	Total	222	324	1467	3441	1684	535	562	316	575	374	253	300
Chalone Pk	Wkend	*	146	180	254	213	184	89	91	141	222	193	151
	Wkday	*	54	88	149	170	82	62	26	56	37	117	117
	Total	100	200	268	403	383	266	151	117	197	259	310	268
Condor Gulch	Wkend	1078	773	1550	1913	1259	1020	1094	720	834	979	1199	833
	Wkday	1818	490	940	1904	1030	722	845	561	550	654	671	768
	Total	2896	1263	2490	3817	2289	1742	1939	1281	1384	1633	1870	1601
High Pks(Chalone)	Wkend	473	214	1004	1899	748	224	225	111	287	486	432	178
	Wkday	239	74	202	396	382	113	113	59	92	112	183	285
	Total	712	288	1206	2295	1130	337	338	170	379	598	615	463
Moses Spring	Wkend	994	615	*	2778	1328	1774	2064	1321	1505	1555	1674	1166
	Wkday	1382	356	*	2347	2131	775	1576	838	1163	540	1015	1083
	Total	2376	1209	2300	5125	3459	2549	3640	2159	2668	2095	2689	2249
Old Pinn	Wkend	1076	653	2480	2999	2939	1500	1757	1103	1283	1702	1169	490
	Wkday	1361	202	570	1791	914	780	1255	550	490	340	485	587
	Total	2437	855	3050	4790	3853	2280	3012	1653	1773	2042	1654	1077
Rim Trail	Wkend	*	1179	1412	1828	1048	560	443	346	539	603	2080	561
	Wkday	*	1550	950	1394	644	382	1139	374	225	596	1648	458
	Total	4000	2729	2362	3222	1692	942	1582	720	764	1199	3728	1019
South Wild.	Wkend	*	26	15	52	16	19	27	42	6	35	37	34
	Wkday	*	17	7	77	10	32	24	28	35	36	15	8
	Total	30	43	22	129	26	51	51	70	41	71	52	42
WEST SIDE													
Balconies Cave	Wkend	1088	678	2299	3479	2541	1911	3179	1981	*	1922	1529	1187
	Wkday	523	198	761	1862	1075	1132	2215	1643	*	482	1512	1185
	Total	1611	876	3060	5341	3616	3043	5394	3624	3300	2404	3041	2372
Balconies Trail	Wkend	1490	897	3019	4092	2452	1591	2655	1321	2300	1488	2066	1570
	Wkday	709	874	1497	2190	1544	1252	2214	1384	1018	617	1180	1415
	Total	2199	1771	4516	6282	3966	2843	4869	2705	3318	2105	3246	2985
Juniper Canyon	Wkend	714	552	1492	2302	852	1562	688	385	1075	667	850	555
	Wkday	408	385	974	2113	1018	1462	559	882	435	474	645	650
	Total	1122	937	2466	4415	1870	3024	1247	1267	1510	1141	1495	1205

		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
North Wild.	Wkend	75	31	104	266	105	162	468	38	145	55	56	36
	Wkday	21	26	223	111	171	123	166	119	51	175	44	65
	Total	96	57	327	377	276	285	634	157	196	230	100	101

Appendix C. 2001 counts for trails at PNM month showing totals and subtotals by weekend and weekday.

TRAIL	Totals:	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
EAST SIDE													
Bear Gulch	Wkend	233	210	1014	1973	1065	468	363	165	401	503	415	59
	Wkday	104	78	174	553	702	239	211	168	473	325	155	63
	Total	337	210	1188	2526	1767	707	574	333	874	828	570	122
Chalone Pk	Wkend	200	264	366	381	360	160	121	138	78	270	178	39
	Wkday	94	76	204	279	197	90	89	48	240	96	89	78
	Total	294	340	570	660	557	250	210	186	318	366	267	117
Condor Gulch	Wkend	750	774	1537	2364	1771	938	652	710	1341	1197	913	417
	Wkday	275	556	1107	1688	1114	456	563	647	560	709	790	583
	Total	1025	1330	2644	4052	2885	1394	1215	1357	1901	1906	1703	1000
H.Pks Chal.	Wkend	183	224	703	1273	663	248	245	150	307	400	584	100
	Wkday	342	183	586	1061	552	206	193	114	113	157	155	735
	Total	525	407	1289	2334	1215	454	438	264	420	557	739	835
Moses Spring	Wkend	1305	959	1891	2590	*	2726	2287	1833	2473	1760	1699	1746
	Wkday	1056	998	1423	2380	*	1036	1348	1385	2376	1631	2008	1343
	Total	2361	1957	3314	4970	3354	3726	3635	3218	4849	3391	3707	3089
Old Pinn	Wkend	666	578	2061	3563	3085	1798	1413	1341	1738	1748	1210	234
	Wkday	431	443	463	1447	342	607	657	815	672	375	394	397
	Total	1097	1021	2524	5010	3427	2405	2070	2156	2410	2123	1604	631
South Wilderness	Wkend	12	11	46	186	54	104	19	7	34	59	33	*
	Wkday	29	24	41	129	50	91	45	131	36	44	49	*
	Total	41	35	87	315	104	195	64	138	70	103	82	66
WEST SIDE													
Balconies Trail	Wkend	1451	1244	3396	4936	3691	2242	1794	1996	2405	1301	1698	853
	Wkday	1447	691	1422	2882	1988	1203	1171	1795	875	724	1382	1142
	Total	2898	1935	4818	7818	5679	3445	2695	3791	3280	2025	3080	1995
Balconies Cave	Wkend	952	968	2484	5132	4749	2660	2697	2351	2980	1952	1987	591
	Wkday	1010	581	826	2395	1637	1098	1562	1753	966	760	869	803
	Total	1962	1549	3310	7527	6386	3758	4259	4104	3946	2712	2856	1394
Juniper Canyon	Wkend	662	1496	2369	2095	1219	717	597	598	525	720	676	514
	Wkday	492	670	990	1060	1918	1146	411	534	329	463	456	1098
	Total	1154	2166	3359	3155	3137	1863	1008	1132	854	1183	1132	1612

North Wilderness	Wkend	92	26	349	606	247	41	156	19	105	66	53	84
	Wkday	30	78	30	147	72	383	81	64	43	57	84	46
	Total	122	104	379	753	319	424	237	83	148	123	137	130

Appendix D. Data processing procedures.

1) I scanned the data for unusually large counts while entering it into Minitab. If there were no obvious abnormalities, I coded the data for weekday or weekend and tallied the counts (table below).

Month	Day	Hour	Minute	Code
12	1	9	12	Wkend
12	1	9	12	Wkend
12	1	9	51	Wkend
12	1	9	53	Wkend
12	1	9	53	Wkend
12	1	10	24	Wkend
12	1	10	57	Wkend
12	1	10	57	Wkend
12	1	10	57	Wkend
12	1	11	7	Wkend
12	1	11	10	Wkend

2) I examined a suspect dataset by tallying the whole dataset for a given month by hour – December in this case.

Hour	Count
0	113
1	14
2	23
3	27
4	72
5	22
6	11
7	117
8	44
9	188
10	40
11	69
12	505
13	188
14	254
15	96
16	88
17	24
18	1
19	23

3) If abnormalities were present, as in this case (many counts are shown for hours when the monument was closed) I coded the data to separate out the hours when people were not likely to be present – for example between 0 and 0700 hours and between 2100 and 2400 hours. I then separated out those hours and coded the remaining data weekend of weekday, as above, and tallied.

4) Tallied sums for uncorrected and corrected data shown below.

```
Code    Count
Wkday   1329
Wkend    682
   N=    2011



Code    Count
Wkday   1098
Wkend    514
   N=    1612
```

5) Finally, I entered the corrected data into the yearly table (MS Excel) which displayed total counts by month with weekday and weekend subtotals for each trail. If whole blocks of data were "bad" for a given counter (e.g., there were missing days due to dead batteries or receivers at full memory capacity) I attempted to fill in the holes using 2 basic methods. For situations where data for most of the month was good, I calculated average daily use for weekends and weekdays based on the good data and multiplied these values by the number of missing days. If data for most of a month was missing (fortunately a rare event) due to a series of errors or malfunctions, I used a combination of multiple regression and ratios based on the counts of more reliable units to fill in data gaps. The most problematic units were Juniper Canyon, High Peaks Chalone, South Wilderness, and the Rim Trail unit for 2000 only, as it was relocated early in 2001.